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VIII. *Observations on the Effects which take place from the Destruction of the Membrana Tympani of the Ear. By Mr. Astley Cooper. In a Letter to Everard Home, Esq. F. R. S. by whom some Remarks are added.*

Read February 6, 1800.

DEAR SIR,

AT the time you were engaged in the investigation of the structure and uses of the membrana tympani, you mentioned a wish to ascertain the effect a rupture of that membrane would have upon hearing. I now send you some observations on that subject, which, if you think them of sufficient importance, you will do me the honour of presenting to the Royal Society.

I am, &c.

ASTLEY COOPER.

ANATOMISTS have endeavoured to ascertain, by experiments on quadrupeds, the loss of power which the organ of hearing would sustain by perforating the membrana tympani: dogs have been made the subject of these trials; but the results have been neither clear nor satisfactory, and they accord but little with the phænomena I am about to relate.

Mr. CHESELDEN had conceived the design of making the human organ itself the subject of direct experiment; and a con-

demned criminal was pardoned, on condition of his submitting to it; but, a popular outcry being raised, it was thought proper to relinquish the idea.

Though denied the aid of experiment, we are not without the means of obtaining knowledge upon such subjects; since the changes produced by disease, frequently furnish a clue which is equally satisfactory.

It often happens, that some parts of an organ are destroyed by disease, whilst others are left in their natural state; and hence, by the powers retained by such organ, after a partial destruction, we are enabled to judge of the functions performed by those parts, when the whole was in health.

Guided by this principle, I have made the human ear the subject of observation, and have endeavoured to ascertain the degree of loss it sustains in its powers by the want of the *membrana tympani*; a membrane which has been generally considered, from its situation in the meatus, and its connection with the adjacent parts by a beautiful and delicate structure, as essentially necessary to the sense of hearing; but which, as appears by the following observations, may be lost, with little prejudice to the functions of the organ.

Mr. P——, a medical student at St. Thomas's Hospital, of the age of twenty years, applied to me, in the winter of 1797, while he was attending a course of anatomical lectures, requesting my opinion upon the nature of a complaint in his ear, which had long rendered him slightly deaf.

Upon inquiring into the nature of the symptoms which had preceded, and of those which now accompanied the disease, he informed me, that he had been subject from his infancy to pains in the head, and was attacked, at the age of ten years, with an in-

flammation and suppuration in the left ear, which continued discharging matter for several weeks: in the space of about twelve months after the first attack, symptoms of a similar kind took place in the right ear, from which also matter issued for a considerable time. The discharge in each instance was thin, and extremely offensive to the smell; and, in the matter, bones or pieces of bones were observable. The immediate consequence of these attacks was a total deafness, which continued for three months; the hearing then began to return, and, in about ten months from the last attack, was restored to the state in which it at present remains.

Having thus described the disease and its symptoms, he gave me the following satisfactory proof of each *membrana tympani* being imperfect. Having filled his mouth with air, he closed the nostrils, and contracted his cheeks: the air, thus compressed, was heard to rush through the *meatus auditorius*, with a whistling noise, and the hair hanging from the temples became agitated by the current of air which issued from the ear. To determine this with greater precision, I called for a lighted candle, which was applied in turn to each ear, and the flame was agitated in a similar manner. Struck with the novelty of these phænomena, I wished to have many witnesses of them, and therefore requested him, at the conclusion of the lecture upon the organ of hearing, to exhibit them to his fellow students, with which request he was so obliging as to comply.

It was evident from these experiments, that the *membrana tympani* of each ear was incomplete, and that the air issued from the mouth, by the Eustachian tube, through an opening in that membrane, and escaped by the external *meatus*.

To determine the degree in which the *membrana tympani*

had been injured, I passed a probe into each ear, and found that the membrane on the left side was entirely destroyed; since the probe struck against the petrous portion of the temporal bone, at the interior part of the tympanum, not by passing through a small opening; for, after an attentive examination, the space usually occupied by the membrana tympani was found to be an aperture, without one trace of membrane remaining.

On the right side also, a probe could be passed into the cavity of the tympanum; but here, by conducting it along the sides of the meatus, some remains of the circumference of the membrane could be discovered, with a circular opening in its centre, about the fourth of an inch in diameter.

From such a destruction of this membrane, partial indeed in one ear, but complete in the other, it might be expected that a total annihilation of the powers of the organ would have followed: but the deafness was inconsiderable. This gentleman, if his attention were exerted, was capable, when in company, of hearing whatever was said in the usual tone of conversation; and it is worthy of remark, that he could hear with the left ear better than with the right, though in the left no traces of the membrana tympani could be perceived.

When attending the anatomical lectures also, he could hear, even at the most distant part of the theatre, every word that was delivered; though, to avoid the regular and constant exertion which it required, he preferred placing himself near the lecturer.

I found, however, that when a note was struck upon the piano forte, he could hear it only at two thirds of the distance at which I could hear it myself; and he informed me, that in a voyage he had made to the East Indies, while others, when

ships were hailed at sea, could catch words with accuracy, his organ of hearing received only an indistinct impression. But the most extraordinary circumstance in Mr. P—'s case is, that the ear was nicely susceptible of musical tones; *for he played well on the flute, and had frequently borne a part in a concert.* I speak this, not from his own authority only, but also from that of his father, who is an excellent judge of music, and plays well on the violin: he told me, that his son, besides playing on the flute, sung with much taste, and perfectly in tune.

The slight degree of deafness of which Mr. P— complained, was always greatly increased by his catching cold: an effect which seems to have arisen from the meatus being closed by an accumulation of the natural secretion of the ear; for it frequently happened to him, after he had been some time deaf from cold, that a large piece of hardened wax, during a fit of coughing, was forced from the ear, by the air rushing from the mouth through the Eustachian tube, and his hearing was instantly restored.

From bathing likewise he suffered considerable inconvenience, unless his ears were guarded against the water, by cotton being previously forced into the meatus. When this precaution was neglected, the water, as he plunged in, by rushing into the interior parts of the ears, occasioned violent pain, and brought on a deafness, which continued until the cause was removed, that is, until the water was discharged: but he had acquired the habit of removing it, by forcing air from the mouth through the ear.

In a healthy ear, when the meatus auditorius is stopped by the finger, or is otherwise closed, a noise similar to that of a distant roaring of the sea is produced: this arises from the air in the meatus being compressed upon the membrana tympani. In

the case here described, no such sensation was produced : for, in Mr. P's ear, the air, meeting with no impediment, could suffer no compression ; since it found a passage, through the open membrane, to the mouth, by means of the Eustachian tube.

Mr. P— was liable to the sensation commonly called the *teeth being on edge*, in the same degree as it exists in others ; and it was produced by similar acute sounds, as by the filing of a saw, the rubbing of silk, &c. Its occurring in him seems to disprove the idea which has been entertained of its cause ; for it has been thought, that the close connection of the nerve called the *corda tympani* with the *membrana tympani*, exposed it to be affected by the motions of the malleus ; and that, as it passes to nerves connected with the teeth, they would suffer from the vibratory state of the nerve, produced by the agitations of the membrane. But, in this case, as the membrane was entirely destroyed on that side on which the sensation was produced, some other explanation must be resorted to ; and I see no reason why this effect should not be referred to that part of the auditory nerve which lines the labyrinth of the ear, which, being impressed by acute and disagreeable sounds, would convey the impression to the *portio dura* of the same nerve, and to the teeth with which that nerve is connected.

The external ear, though two distinct muscles are inserted into it, is capable, in its natural state, of little motion ; however, when an organ becomes imperfect, every agent which can be employed to increase its powers is called into action ; and, in the case here described, the external ear had acquired a distinct motion upward and backward, which was observable whenever Mr. P— listened to any thing which he did not distinctly hear. This power over the muscles was so great, that when desired

to raise the ear, or to draw it backwards, he was capable of moving it in either direction.

This case is not the only one of this description which has come under my observation; for another gentleman, Mr. A—, applied to me under a similar complaint, (but in one ear only,) proceeding from suppuration, and producing the same effects. This gentleman has the same power of forcing air through the imperfect ear; suffers equally from bathing, if the meatus auditorius be unprotected; and feels, even from exposure to a stream of cold air, very considerable pain. The only difference I could observe was, that in Mr. A's case, the defect of hearing in the diseased organ was somewhat greater than in the former; for though, when his sound ear was closed, he could hear what was said in a common tone of voice, yet he could not distinguish the notes of a piano forte at the same distance: a difference which might have in part arisen from the confused noise which is always produced by closing the sound ear; or because, as he heard well on one side, the imperfect ear had remained unemployed, and consequently had been enfeebled by disuse.

From these observations it seems evidently to follow, that the loss of the membrana tympani in both ears, far from producing total deafness, occasions only a slight diminution of the powers of hearing.

Anatomists who have destroyed this membrane in dogs, have asserted, that at first the effect on the sense of hearing was trivial; but that, after the lapse of a few months, a total deafness ensued. Baron HALLER also has said, that if the membrane of the tympanum be broken, the person becomes at first hard of hearing, and afterwards perfectly deaf. But, in these instances, the destruction must have extended further than the membrana

tympani; and the labyrinth must have suffered from the removal of the stapes, and from the consequent discharge of water contained in the cavities of the internal ear; for it has been very constantly observed, that when all the small bones of the ear have been discharged, a total deafness has ensued.

It is probable, that in instances in which the membrana tympani is destroyed, the functions of this membrane have been carried on by the membranes of the fenestra ovalis and fenestra rotunda: for, as they are placed over the water of the labyrinth, they will, when agitated by the impressions of sound, convey their vibrations to that fluid in a similar manner, though in somewhat an inferior degree, to those which are conveyed by means of the membrana tympani and the small bones which are attached to it; and thus, in the organ of hearing, each part is admirably adapted, not only to the purpose for which it is designed, but also as a provision against accident or disease; so that, whenever any particular part is destroyed, another is substituted for it, and the organ, from this deprivation, suffers but little injury in its functions.

It seems that the principal use of the membrana tympani is, to modify the impressions of sound, and to proportion them to the powers and expectation of the organ. Mr. P— had lost this power for a considerable period after the destruction of the membrane; but, in process of time, as the external ear acquired the additional motions I have described, sounds were rendered stronger or weaker by them. When, therefore, he was addressed in a whisper, the ear was seen immediately to move; but, when the tone of voice was louder, it then remained altogether motionless.

Some additional Remarks, on the Mode of Hearing in Cases where the Membrana Tympani has been destroyed. By EVERARD HOME, Esq.

After having communicated to this learned Society, the very curious facts contained in Mr. COOPER's paper, which prove that the organ of hearing is capable of receiving all the different impressions of sound, when the membrana tympani has been destroyed, it may not be improper to explain, from the observations contained in a former paper on this subject, in what manner this may take place.

It is there stated, that any vibrations communicated directly to the bones of the skull, are as accurately impressed upon the organ, as through the medium of the membrana tympani. The office of that membrane is therefore to afford an extended surface, capable of receiving impressions from the external air, and of communicating them to the small bones of the ear; which a membrane would be incapable of doing, unless it had a power of varying its tension, to adapt it to different vibrations.

In the above cases, in which this membrane, the malleus, and the incus, had been destroyed, it would appear that the stapes was acted upon by the air received into the cavity of the tympanum, and communicated the impressions immediately to the internal organ. This not happening for some months after the membrane was destroyed, probably arose from the inflammation of the tympanum confining the stapes, and rendering its vibrations imperfect.

That sounds can be communicated with accuracy by the bones of the skull, to the internal organ, when received from solid or liquid substances, has long been well understood.

That the membrana tympani is incapable of perfectly answering this purpose, when sounds are propagated through air, has been a generally received opinion ; to refute which, was the object of my former paper. That, in cases in which the membrana tympani has been destroyed, the air is capable of acting with sufficient force upon the stapes to communicate vibrations to it, and to produce on the internal organ the necessary effect for perfect hearing, is completely ascertained by Mr. COOPER's observations.